

Guidelines: Adult advanced life support

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1. The guideline process

The process used to produce the Resuscitation Council UK Guidelines 2015 has been accredited by the National Institute for Health and Care Excellence. The guidelines process includes:

- Systematic reviews with grading of the quality of evidence and strength of recommendations. This led to the 2015 International Liaison Committee on Resuscitation (ILCOR) Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. 1,2
- The involvement of stakeholders from around the world including members of the public and cardiac arrest survivors.
- Details of the guidelines development process can be found in the [Resuscitation Council UK Guidelines Development Process Manual](#).
- These Resuscitation Council UK Guidelines have been peer reviewed by the Executive Committee of Resuscitation Council UK, which comprises 25 individuals and includes lay representation and representation of the key stakeholder groups.

2. Summary of changes in advanced life support since 2010 Guidelines

The 2015 Advanced life support (ALS) guidelines have a change in emphasis aimed at improved care and implementation of these guidelines in order to improve patient outcomes.³ The key changes since 2010 are:

- Increased emphasis on minimally interrupted high-quality chest compressions throughout any ALS intervention.
- Chest compressions must only be paused briefly to enable specific interventions. This includes minimising interruptions in chest compressions to less than 5 seconds when attempting defibrillation or tracheal intubation.
- There is a new section on monitoring during ALS.
- Waveform capnography must be used to confirm and continually monitor tracheal tube placement, and may be used to monitor the quality of CPR and to provide an early indication of return of spontaneous circulation (ROSC).
- There are a variety of approaches to airway management during CPR and a stepwise approach based on patient factors and the skills of the rescuer is recommended.
- The recommendations for drug therapy during CPR have not changed, but there is equipoise for the role of drugs in improving outcomes from cardiac arrest.
- The routine use of mechanical chest compression devices is not recommended, but they may be useful in situations where sustained high quality manual chest compressions are impractical or compromise provider safety.
- Peri-arrest ultrasound may be used to identify reversible causes of cardiac arrest.
- Extracorporeal life support techniques may be used as a rescue therapy in selected patients where standard ALS measures are not successful.
- The ALS algorithm (Figure 1) has been modified slightly to show these changes.

Figure 1. Adult advanced life support algorithm

3. Introduction

This section on Adult advanced life support (ALS) adheres to the same general principles as Guidelines 2010, but incorporates some important changes. The guidelines in this section apply to healthcare professionals trained in ALS

techniques. Laypeople, first responders, and automated external defibrillator (AED) users are referred to the [Adult basic life support and automated external defibrillation section](#).

Adult ALS includes advanced interventions after basic life support has started and when appropriate an AED has been used. The transition between basic and advanced life support should be seamless as BLS will continue during and overlap with ALS interventions. [Post-resuscitation care guidelines](#) are presented in a new section that recognises the importance of the final link in the Chain of Survival.⁴

These guidelines are based on the International Liaison Committee on Resuscitation (ILCOR) 2015 Consensus on Science and Treatment Recommendations (CoSTR) for ALS² and the European Resuscitation Council 2015 Advanced Life Support Guidelines.⁵ These contain all the reference material for this section.

4. ALS treatment algorithm

Heart rhythms associated with cardiac arrest are divided into two groups: shockable rhythms (ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT)) and non-shockable rhythms (asystole and pulseless electrical activity (PEA)). The main difference in the treatment of these two groups is the need for attempted defibrillation in patients with VF/pVT.

Other actions, including chest compression, airway management and ventilation, vascular access, administration of adrenaline, and the identification and correction of reversible factors, are common to both groups. The ALS algorithm provides a standardised approach to the management of adult patients in cardiac arrest.

Drugs and advanced airways are still included among ALS interventions, but are of secondary importance to early defibrillation and high quality, uninterrupted chest compressions. At the time of writing these guidelines, three large randomised controlled trials (RCTs) (adrenaline versus placebo [ISRCTN73485024], amiodarone versus lidocaine versus placebo⁶ [NCT01401647] and supraglottic airway (i-gel) versus tracheal intubation [ISRCTN No: 08256118]) are currently ongoing.

Shockable rhythms (VF/pVT)

The first monitored rhythm is VF/pVT in approximately 20% of both in-hospital⁷ and out-of-hospital cardiac arrests (OHCAs).⁸ Ventricular fibrillation/pulseless ventricular tachycardia will also occur at some stage during resuscitation in about 25% of cardiac arrests with an initial documented rhythm of asystole or PEA.^{9,10}

Treatment of shockable rhythms (VF/VT)

1. Confirm cardiac arrest – check for signs of life and normal breathing and, if trained to do so, check for breathing and a pulse simultaneously.
2. Call resuscitation team.
3. Perform uninterrupted chest compressions while applying self-adhesive defibrillation/monitoring pads – one below the right clavicle and the other in the V6 position in the midaxillary line.
4. Plan actions before pausing CPR for rhythm analysis and communicate these to the team.
5. Stop chest compressions; confirm VF/pVT from the ECG. This pause in chest compressions should be brief and no longer than 5 seconds.
6. Resume chest compressions immediately; warn all rescuers other than the individual performing the chest compressions to “stand clear” and remove any oxygen delivery device as appropriate.
7. The designated person selects the appropriate energy on the defibrillator and presses the charge button. Choose an energy setting of at least 150 J for the first shock, the same or a higher energy for subsequent shocks, or follow the manufacturer’s guidance for the particular defibrillator. If unsure of the correct energy level for a defibrillator choose the highest available energy.
8. Ensure that the rescuer giving the compressions is the only person touching the patient.
9. Once the defibrillator is charged and the safety check is complete, tell the rescuer doing the chest compressions to “stand clear”; when clear, give the shock.
10. After shock delivery immediately restart CPR using a ratio of 30:2, starting with chest compressions. Do not pause to reassess the rhythm or feel for a pulse. The total pause in chest compressions should be brief and no longer than 5 seconds.

11. Continue CPR for 2 min; the team leader prepares the team for the next pause in CPR.
12. Pause briefly to check the monitor.
13. If VF/pVT, repeat steps 6–12 above and deliver a second shock.
14. If VF/pVT persists, repeat steps 6–8 above and deliver a third shock. Resume chest compressions immediately. Give adrenaline 1 mg IV and amiodarone 300 mg IV while performing a further 2 min CPR. Withhold adrenaline if there are signs of return of spontaneous circulation (ROSC) during CPR.
15. Repeat this 2 min CPR – rhythm/pulse check – defibrillation sequence if VF/pVT persists.
16. Give further adrenaline 1 mg IV after alternate shocks (i.e. approximately every 3–5 min).
17. If organised electrical activity compatible with a cardiac output is seen during a rhythm check, seek evidence of ROSC (check for signs of life, a central pulse and end-tidal CO₂ if available).
 - If there is ROSC, start post-resuscitation care.
 - If there are no signs of ROSC, continue CPR and switch to the non-shockable algorithm.
18. If asystole is seen, continue CPR and switch to the nonshockable algorithm.

The interval between stopping compressions and delivering a shock must be minimised. Longer interruptions to chest compressions reduce the chance of a shock restoring a spontaneous circulation. Chest compressions are resumed immediately after delivering a shock (without checking the rhythm or a pulse) because even if the defibrillation attempt is successful in restoring a perfusing rhythm, it is very rare for a pulse to be palpable immediately after defibrillation. The duration of asystole before ROSC can be longer than 2 min in as many as 25% of successful shocks.¹¹ If a shock has been successful immediate resumption of chest compressions does not increase the risk of VF recurrence.¹² Furthermore, the delay in trying to palpate a pulse will further compromise the myocardium if a perfusing rhythm has not been restored.¹³

The use of waveform capnography can enable ROSC to be detected without pausing chest compressions and may be used as a way of avoiding a bolus injection of adrenaline after ROSC has been achieved. Several human studies have shown that there is a significant increase in end-tidal CO₂ when ROSC occurs.^{5,14} If ROSC is suspected during CPR, withhold adrenaline. Give adrenaline if cardiac arrest is confirmed at the next rhythm check.

Regardless of the arrest rhythm, after the initial adrenaline dose has been given,

give further doses of adrenaline 1 mg every 3–5 min until ROSC is achieved; in practice, this will be about once every two cycles of the algorithm. If signs of life return during CPR (e.g. purposeful movement, normal breathing or coughing), or there is an increase in end-tidal CO₂, check the monitor; if an organised rhythm is present, check for a pulse. If a pulse is palpable, start post-resuscitation care. If no pulse is present, continue CPR.

Give amiodarone 300 mg IV after three defibrillation attempts irrespective of whether they are consecutive shocks, or interrupted by CPR, or for recurrent VF/pVT during cardiac arrest. Consider a further dose of amiodarone 150 mg IV after a total of five defibrillation attempts. Lidocaine 1 mg kg⁻¹ may be used as an alternative if amiodarone is not available but do not give lidocaine if amiodarone has been given already.

Witnessed, monitored VF/pVT

If a patient has a monitored and witnessed cardiac arrest in the catheter laboratory, coronary care unit, a critical care area or whilst monitored after cardiac surgery, and a manual defibrillator is rapidly available:

Confirm cardiac arrest and shout for help.

If the initial rhythm is VF/pVT, give up to three quick successive (stacked) shocks.

Rapidly check for a rhythm change and, if appropriate, ROSC after each defibrillation attempt.

Start chest compressions and continue CPR for 2 min if the third shock is unsuccessful.

This three-shock strategy may also be considered for an initial, witnessed VF/pVT cardiac arrest if the patient is already connected to a manual defibrillator – these circumstances are rare. Although there are no data supporting a three-shock strategy in any of these circumstances, it is unlikely that chest compressions will improve the already very high chance of ROSC when defibrillation occurs early in the electrical phase, immediately after onset of VF/pVT.

If this initial three-shock strategy is unsuccessful for a monitored VF/pVT cardiac arrest, the ALS algorithm should be followed and these three-shocks treated as if only the first single shock has been given.

Precordial thump

A single precordial thump has a very low success rate for cardioversion of a shockable rhythm.¹⁵⁻¹⁹ Its routine use is therefore not recommended. Consider a precordial thump only when it can be used without delay whilst awaiting the arrival of a defibrillator in a monitored VF/pVT arrest. Using the ulnar edge of a tightly clenched fist, deliver a sharp impact to the lower half of the sternum from a height of about 20 cm, then retract the fist immediately to create an impulse-like stimulus.

Non-shockable rhythms (PEA and asystole)

Pulseless electrical activity (PEA) is defined as cardiac arrest in the presence of electrical activity (other than ventricular tachyarrhythmia) that would normally be associated with a palpable pulse.²⁰ These patients often have some mechanical myocardial contractions, but these are too weak to produce a detectable pulse or blood pressure – this is sometimes described as ‘pseudo-PEA’ (see below). PEA can be caused by reversible conditions that can be treated if they are identified and corrected. Survival following cardiac arrest with asystole or PEA is unlikely unless a reversible cause can be found and treated effectively.

Treatment of PEA and asystole

1. Start CPR 30:2
2. Give adrenaline 1 mg IV as soon as intravascular access is achieved
3. Continue CPR 30:2 until the airway is secured – then continue chest compressions without pausing during ventilation
4. Recheck the rhythm after 2 min.

If electrical activity compatible with a pulse is seen, check for a pulse and/or signs of life:

- If a pulse and/or signs of life are present, start post resuscitation care
- If no pulse and/or no signs of life are present (PEA OR asystole):
 - Continue CPR
 - Recheck the rhythm after 2 min and proceed accordingly
 - Give further adrenaline 1 mg IV every 3–5 min (during alternate 2-min loops of CPR)

If VF/pVT at rhythm check: change to shockable side of algorithm.

Whenever a diagnosis of asystole is made, check the ECG carefully for the presence of P waves because the patient may respond to cardiac pacing when there is ventricular standstill with continuing P waves. There is no value in attempting to pace true asystole.

5. Treat reversible causes

Potential causes or aggravating factors for which specific treatment exists must be considered during all cardiac arrests.²¹ For ease of memory, these are divided into two groups of four, based upon their initial letter: either H or T:

- Hypoxia
- Hypovolaemia
- Hyperkalaemia, hypokalaemia, hypoglycaemia, hypocalcaemia, acidaemia and other metabolic disorders
- Hypothermia
- Thrombosis (coronary or pulmonary)
- Tension pneumothorax
- Tamponade – cardiac
- Toxins

The four 'Hs'

Minimise the risk of **hypoxia** by ensuring that the patient's lungs are ventilated adequately with the maximal possible inspired oxygen during CPR. Make sure there is adequate chest rise and bilateral breath sounds. Using the techniques described below, check carefully that the tracheal tube is not misplaced in a bronchus or the oesophagus.

Pulseless electrical activity caused by **hypovolaemia** is due usually to severe haemorrhage. This may be precipitated by trauma, gastrointestinal bleeding or rupture of an aortic aneurysm. Stop the haemorrhage and restore intravascular volume with fluid and blood products.

Hyperkalaemia, hypokalaemia, hypocalcaemia, acidaemia and other metabolic disorders are detected by biochemical tests or suggested by the patient's

medical history (e.g. renal failure). Give IV calcium chloride in the presence of hyperkalaemia, hypocalcaemia and calcium channel-blocker overdose.

Hypothermia should be suspected based on the history such as cardiac arrest associated with drowning.

The four 'Ts'

Coronary **thrombosis** associated with an acute coronary syndrome or ischaemic heart disease is the most common cause of sudden cardiac arrest. An acute coronary syndrome is usually diagnosed and treated after ROSC is achieved. If an acute coronary syndrome is suspected, and ROSC has not been achieved, consider urgent coronary angiography when feasible and, if required, percutaneous coronary intervention. Mechanical chest compression devices and extracorporeal CPR can help facilitate this (see below).

The commonest cause of thromboembolic or mechanical circulatory obstruction is massive pulmonary embolism. If pulmonary embolism is thought to be the cause of cardiac arrest consider giving a fibrinolytic drug immediately. Following fibrinolysis during CPR for acute pulmonary embolism, survival and good neurological outcome have been reported, even in cases requiring in excess of 60 min of CPR. If a fibrinolytic drug is given in these circumstances, consider performing CPR for at least 60–90 min before termination of resuscitation attempts. In some settings extracorporeal CPR, and/or surgical or mechanical thrombectomy can also be used to treat pulmonary embolism.

A **tension pneumothorax** can be the primary cause of PEA and may be associated with trauma. The diagnosis is made clinically or by ultrasound. Decompress rapidly by thoracostomy or needle thoracocentesis, and then insert a chest drain.

Cardiac **tamponade** is difficult to diagnose because the typical signs of distended neck veins and hypotension are usually obscured by the arrest itself. Cardiac arrest after penetrating chest trauma is highly suggestive of tamponade and is an indication for resuscitative thoracotomy. The use of ultrasound will make the diagnosis of cardiac tamponade much more reliable.

In the absence of a specific history, the accidental or deliberate ingestion of therapeutic or **toxic** substances may be revealed only by laboratory

investigations. Where available, the appropriate antidotes should be used, but most often treatment is supportive and standard ALS protocols should be followed.

Use of ultrasound imaging during advanced life support

When available for use by trained clinicians, focused echocardiography/ultrasound may be of use in assisting with diagnosis and treatment of potentially reversible causes of cardiac arrest. The integration of ultrasound into advanced life support requires considerable training if interruptions to chest compressions are to be minimised. A sub-xiphoid probe position has been recommended.²²⁻²⁴ Placement of the probe just before chest compressions are paused for a planned rhythm assessment enables a well-trained operator to obtain views within 10 seconds.

Several studies have examined the use of ultrasound during cardiac arrest to detect potentially reversible causes.²⁵⁻²⁷ Although no studies have shown that use of this imaging modality improves outcome, there is no doubt that echocardiography has the potential to detect reversible causes of cardiac arrest. Specific protocols for ultrasound evaluation during CPR may help to identify potentially reversible causes (e.g. cardiac tamponade, pulmonary embolism, hypovolaemia, pneumothorax). Absence of cardiac motion on sonography during resuscitation of patients in cardiac arrest is highly predictive of death although sensitivity and specificity has not been reported.²⁸⁻³¹

6. During CPR

Please find below key information you may need to know during CPR:

High quality chest compressions with minimal interruption

During the treatment of persistent VF/pVT or PEA/asystole, there should be an emphasis on giving high quality chest compression between defibrillation attempts or rhythm checks, whilst recognising and treating reversible causes (4 Hs and 4 Ts), and whilst obtaining a secure airway and intravascular access. Aim for a chest compression pause of less than 5 seconds for rhythm checks, defibrillation attempts, and tracheal intubation. To achieve this, rescuers must

plan their actions before pausing compressions.

Monitoring during advanced life support

The following methods can be used to monitor the patient during CPR and help guide ALS interventions:

- Clinical signs such as breathing efforts, movements and eye opening can occur during CPR. These can indicate ROSC and require verification by a rhythm and pulse check, but can also occur because CPR can generate a sufficient circulation to restore signs of life including consciousness.³²
- Pulse checks when there is an ECG rhythm compatible with an output can be used to identify ROSC, but may not detect pulses in those with low cardiac output states and a low blood pressure.³³ The value of attempting to feel arterial pulses during chest compressions to assess the effectiveness of chest compressions is unclear. A pulse that is felt in the femoral triangle may indicate venous rather than arterial blood flow. There are no valves in the inferior vena cava and retrograde blood flow into the venous system can produce femoral vein pulsations.³⁴ Carotid pulsation during CPR does not necessarily indicate adequate myocardial or cerebral perfusion.
- Monitoring heart rhythm through pads, paddles or ECG electrodes is a standard part of ALS. Motion artefacts prevent reliable heart rhythm assessment during chest compressions, forcing rescuers to stop chest compressions to assess the rhythm, and preventing early recognition of recurrent VF/pVT. We suggest that artefact-filtering algorithms are not used for analysis of ECG rhythm during CPR unless as part of a research programme.³⁵
- End-tidal CO₂ with waveform capnography. The use of waveform capnography during CPR has a greater emphasis in Guidelines 2015 and is addressed in more detail below.
- The use of CPR feedback or prompt devices during CPR should be considered only as part of a broader system of care that should include comprehensive CPR quality improvement initiatives³⁶⁻³⁸ rather than an isolated intervention.
- Blood sampling and analysis during CPR can be used to identify potentially reversible causes of cardiac arrest. Avoid finger prick samples in critical illness because they may not be reliable; instead, use samples from veins or arteries.
- Blood gas values are difficult to interpret during CPR. During cardiac arrest,

arterial gas values may be misleading and bear little relationship to the tissue acid-base state.³⁹ Analysis of central venous blood may provide a better estimation of tissue pH.

- Invasive cardiovascular monitoring in critical care settings (e.g. continuous arterial blood pressure and central venous pressure monitoring). Invasive arterial pressure monitoring will enable the detection of low blood pressure values when ROSC is achieved.
- Ultrasound assessment is addressed above to identify and treat reversible causes of cardiac arrest, and identify low cardiac output states ('pseudo-PEA').

Waveform capnography during advanced life support

Use waveform capnography whenever tracheal intubation is undertaken. Although the prevention of unrecognised oesophageal intubation is clearly beneficial, there is currently no evidence that use of waveform capnography during CPR results in improved patient outcomes. The role of waveform capnography during CPR includes:

- Ensuring tracheal tube placement in the trachea (although it will not distinguish between bronchial and tracheal placement).
- Monitoring ventilation rate during CPR and avoiding hyperventilation.
- Monitoring the quality of chest compressions during CPR. End-tidal CO₂ values are associated with compression depth and ventilation rate and a greater depth of chest compression will increase the value.⁴⁰ Whether this can be used to guide care and improve outcome requires further study.⁴¹
- Identifying ROSC during CPR. An increase in end-tidal CO₂ during CPR can indicate ROSC and prevent unnecessary and potentially harmful dosing of adrenaline in a patient with ROSC.^{14,41-43} If ROSC is suspected during CPR, withhold adrenaline. Give adrenaline if cardiac arrest is confirmed at the next rhythm check.
- Prognostication during CPR. Precise values of end-tidal CO₂ depend on several factors including the cause of cardiac arrest, bystander CPR, chest compression quality, ventilation rate and volume, time from cardiac arrest and the use of adrenaline. Values are higher after an initial asphyxial arrest, with bystander CPR, and decline over time after cardiac arrest.^{41,44,45} Low end-tidal CO₂ values during CPR have been associated with lower ROSC rates and increased mortality, and high values with better ROSC and survival.^{41,46,47} The inter-individual differences and influence of cause of cardiac arrest, the problem with self-fulfilling prophecy in studies, our lack of confidence in the accuracy of measurement during CPR, and the need for

an advanced airway to measure end-tidal CO₂ reliably limits our confidence in its use for prognostication. Resuscitation Council UK recommends that a specific end-tidal CO₂ value at any time during CPR should not be used alone to stop CPR efforts. End-tidal CO₂ values should be considered only as part of a multi-modal approach to decision-making for prognostication during CPR.

Defibrillation

This section predominantly addresses the use of manual defibrillators. Guidelines concerning the use of an automated external defibrillator (AED) are addressed in the [Adult basic life support and automated external defibrillation section](#). The defibrillation strategy for the 2015 Resuscitation Guidelines has changed little from the former guidelines:

- The importance of early, uninterrupted chest compressions remains emphasised throughout these guidelines, together with minimising the duration of pre-shock and post-shock pauses – even 5–10 seconds delay will reduce the chances of the shock being successful.⁴⁸⁻⁵³
- Continue chest compressions during defibrillator charging, deliver defibrillation with an interruption in chest compressions of no more than 5 seconds and immediately resume chest compressions following defibrillation.
- Place the right (sternal) electrode to the right of the sternum, below the clavicle. Place the apical paddle in the mid-axillary line, approximately over the V6 ECG electrode position. This electrode should be clear of any breast tissue. It is important that this electrode is placed sufficiently laterally.
- Defibrillation shock energy levels are unchanged from the 2010 Guidelines.
- Deliver the first shock with an energy of at least 150 J.
 - The shock energy for a particular defibrillator should be based on the manufacturer's guidance.
 - Those using manual defibrillators should be aware of the appropriate energy settings for the type of device used, but in the absence of this and if appropriate energy levels are unknown, for adults use the highest available shock energy for all shocks.
 - If an initial shock has been unsuccessful it is worth attempting the second and subsequent shocks with a higher energy level if the defibrillator is capable of delivering a higher energy but, based on current evidence, both fixed and escalating strategies are acceptable.

- If VF/pVT recurs during a cardiac arrest (refibrillation) give subsequent shocks with a higher energy level if the defibrillator is capable of delivering a higher energy.
- There are no high quality clinical studies to indicate the optimal strategies within any given waveform and between different waveforms.² Knowledge gaps include the minimal acceptable first-shock energy level; the characteristics of the optimal biphasic waveform; the optimal energy levels for specific waveforms; and the best shock strategy (fixed versus escalating). It is becoming increasingly clear that selected energy is a poor comparator with which to assess different waveforms as impedance-compensation and subtleties in waveform shape result in significantly different transmural current between devices for any given selected energy. The optimal energy levels may ultimately vary between different manufacturers and associated waveforms. Manufacturers are encouraged to undertake high quality clinical trials to support their defibrillation strategy recommendations.
- No one must touch the patient during shock delivery. Standard clinical examination gloves (or bare hands) do not provide a safe level of electrical insulation.⁵⁴
- Use oxygen safely during defibrillation by:
 - Removing any oxygen mask or nasal cannulae and place them at least 1 m away from the patient's chest during defibrillation.
 - Leaving the ventilation bag connected to the tracheal tube or other airway adjunct. Alternatively, disconnect the ventilation bag from the tracheal tube and move it at least 1 m from the patient's chest during defibrillation.

Airway management and ventilation

The options for airway management and ventilation during CPR vary according to patient factors, the phase of the resuscitation attempt (during CPR, after ROSC), and the skills of rescuers.⁵⁵ They include: no airway and no ventilation (compression-only CPR), compression-only CPR with the airway held open (with or without supplementary oxygen), mouth-to-mouth breaths, mouth-to-mask, bag-mask ventilation with simple airway adjuncts, supraglottic airways (SGAs), and tracheal intubation (inserted with the aid of direct laryngoscopy or videolaryngoscopy, or via a SGA).^{2,5,56,57}

In comparison with bag-mask ventilation and use of a SGA, tracheal intubation

requires considerably more training and practice and can result in unrecognised oesophageal intubation and increased hands-off time. A bag-mask, a SGA and a tracheal tube are frequently used in the same patient as part of a stepwise approach to airway management but this has not been formally assessed.⁵⁶ Patients who remain comatose after initial resuscitation from cardiac arrest will ultimately require tracheal intubation regardless of the airway technique used during cardiac arrest. Anyone attempting tracheal intubation must be well trained and equipped with waveform capnography. Personnel skilled in advanced airway management should attempt laryngoscopy and intubation without stopping chest compressions; a brief pause in chest compressions may be required as the tube is passed through the vocal cords, but this pause should be less than 5 seconds. In the absence of these, use bag-mask ventilation and/or an SGA until appropriately experience and equipped personnel are present.

There is no high quality evidence supporting one particular intervention over another.^{2,57} Depending on the circumstances and the skills of the rescuers, use either an advanced airway (tracheal intubation or supraglottic airway (SGA)) or a bag-mask for airway management during CPR.^{2,5}

Basic airway manoeuvres and airway adjuncts

Assess the airway. Use head tilt and chin lift, or jaw thrust to open the airway. Simple airway adjuncts (oropharyngeal or nasopharyngeal airways) are often helpful, and sometimes essential, to maintain an open airway. When there is a risk of cervical spine injury, establish a clear upper airway by using jaw thrust or chin lift in combination with manual in-line stabilisation of the head and neck by an assistant.^{58,59} If life-threatening airway obstruction persists despite effective application of jaw thrust or chin lift, add head tilt in small increments until the airway is open; establishing a patent airway takes priority over concerns about a potential cervical spine injury.

Oxygen during CPR

During CPR, give the maximal feasible inspired oxygen concentration. There is no data to indicate the optimal arterial blood oxygen saturation (SaO₂) during CPR, and no trials comparing different inspired oxygen concentrations. In one observational study of patients receiving 100% inspired oxygen via a tracheal tube during CPR, a higher measured partial pressure of arterial oxygen (PaO₂) value during CPR was associated with ROSC and hospital admission.⁶⁰ The worse outcomes associated with a low PaO₂ during CPR could, however, be an indication of illness severity.

After ROSC, as soon as arterial blood oxygen saturation can be monitored reliably (by blood gas analysis and/or pulse oximetry), titrate the inspired oxygen concentration to maintain the arterial blood oxygen saturation in the range of 94–98%.² Avoid hypoxaemia, which is also harmful – ensure reliable measurement of arterial oxygen saturation before reducing the inspired oxygen concentration.⁶¹ This is addressed in the [Post-resuscitation care section](#).

Ventilation

Provide artificial ventilation as soon as possible in any patient in whom spontaneous ventilation is inadequate or absent. Expired air ventilation (rescue breathing) is effective but the rescuer's expired oxygen concentration is only 16–17%, so it must be replaced as soon as possible by ventilation with oxygen-enriched air. A pocket resuscitation mask enables mouth-to-mask ventilation and some enable supplemental oxygen to be given. Use a two-hand technique to maximise the seal with the patient's face. A self-inflating bag can be connected to a face mask, tracheal tube, or SGA. The two-person technique for bag-mask ventilation is preferable. Deliver each breath over approximately 1 second and give a volume that corresponds to normal chest movement; this represents a compromise between giving an adequate volume, minimising the risk of gastric inflation, and allowing adequate time for chest compression. During CPR with an unprotected airway, give two ventilations after each sequence of 30 chest compressions. Once a tracheal tube or SGA has been inserted, ventilate the lungs at a rate of about 10 breaths min⁻¹ and continue chest compression without pausing during ventilation.^{2,5}

Alternative airway devices

The tracheal tube has generally been considered the optimal method of managing the airway during cardiac arrest.⁶² There is evidence that, without adequate training and experience, the incidence of complications, such as unrecognised oesophageal intubation (2.4–17% in several studies involving paramedics)^{63–67} and dislodgement, is unacceptably high.⁶⁸ Prolonged attempts at tracheal intubation are harmful; the cessation of chest compressions during this time will compromise coronary and cerebral perfusion. Several alternative airway devices have been used for airway management during CPR.

There are published studies on the use during CPR of the Combitube, the classic laryngeal mask airway (cLMA), the Laryngeal Tube (LT) and the i-gel, and the LMA Supreme (LMAS) but none of these studies has been powered adequately to

enable survival to be studied as a primary endpoint. Instead, most researchers have studied insertion and ventilation success rates. The SGAs are easier to insert than a tracheal tube and,⁶⁹ unlike tracheal intubation, can generally be inserted without interrupting chest compressions.⁷⁰

Laryngeal mask airway (LMA): An LMA is relatively easy to insert, and ventilation using an LMA is more efficient and easier than with a bag-mask. If gas leakage is excessive, chest compression will have to be interrupted to enable ventilation. Although an LMA does not protect the airway as reliably as a tracheal tube, pulmonary aspiration is uncommon when using an LMA during cardiac arrest. The original LMA (classic LMA [cLMA]) has been superseded by several second generation SGAs that have more favourable characteristics, particularly when used for emergency airway management.⁷¹

i-gel: The cuff of the i-gel does not require inflation; the stem of the i-gel incorporates a bite block and a narrow oesophageal drain tube. It is very easy to insert, requiring only minimal training and a laryngeal seal pressure of 20–24 cmH₂O can be achieved.^{72,73} The ease of insertion of the i-gel and its favourable leak pressure make it theoretically very attractive as a resuscitation airway device for those inexperienced in tracheal intubation. In observational studies insertion success rates for the i-gel were 93% (n = 98) when used by paramedics for out-of-hospital cardiac arrest (OHCA)⁷⁴ and 99% (n=100) when used by doctors and nurses for in-hospital cardiac arrest (IHCA).⁷⁵ The i-gel is in widespread use in the UK for both IHCA and OHCA.

LMA Supreme (LMAS): The LMAS is a disposable version of the Proseal LMA, which is used in anaesthetic practice. In an observational study, paramedics inserted the LMAS successfully and were able to ventilate the lungs of 33 (100%) cases of OHCA.⁷⁶

Tracheal intubation

Tracheal intubation should be attempted only by trained personnel able to carry out the procedure with a high level of skill and confidence. No intubation attempt should interrupt chest compressions for more than 5 seconds. Use an alternative airway technique if tracheal intubation is not possible.

Healthcare personnel who undertake prehospital intubation should do so only within a structured, monitored programme, which should include comprehensive competency-based training and regular opportunities to refresh skills. Rescuers must weigh the risks and benefits of intubation against the need to provide

effective chest compressions. The intubation attempt may require some interruption of chest compressions but, once an advanced airway is in place, ventilation will not require interruption of chest compressions. Personnel skilled in advanced airway management should be able to undertake laryngoscopy without stopping chest compressions; a brief pause in chest compressions will be required only as the tube is passed through the vocal cords. Alternatively, to avoid any interruptions in chest compressions, the intubation attempt may be deferred until ROSC;^{77,78} this strategy is being studied in a large prehospital randomised trial.⁷⁹ The intubation attempt should interrupt chest compressions for less than 5 seconds; if intubation is not achievable within these constraints, recommence bag-mask ventilation. After intubation, tube placement must be confirmed and the tube secured adequately.

Videolaryngoscopy: Videolaryngoscopes are being used increasingly in anaesthetic and critical care practice.^{80,81} In comparison with direct laryngoscopy, they enable a better view of the larynx and improve the success rate of intubation. Preliminary studies indicate that use of videolaryngoscopes improve laryngeal view and intubation success rates during CPR⁸²⁻⁸⁴ but further data are required before recommendations can be made for wider use during CPR.

Confirmation of correct placement of the tracheal tube: Resuscitation Council UK recommends using waveform capnography to confirm and continuously monitor the position of a tracheal tube during CPR in addition to clinical assessment. End-tidal CO₂ detectors that include a waveform graphical display (capnographs) are the most reliable for verification of tracheal tube position during cardiac arrest.^{2,5}

Clinical assessment includes observation of chest expansion bilaterally, auscultation over the lung fields bilaterally in the axillae (breath sounds should be equal and adequate) and over the epigastrium (breath sounds should not be heard). Clinical signs of correct tube placement alone (condensation in the tube, chest rise, breath sounds on auscultation of lungs, and inability to hear gas entering the stomach) are not reliable. The reported sensitivity (proportion of tracheal intubations correctly identified) and specificity (proportion of oesophageal intubations correctly identified) of clinical assessment varies: sensitivity 7–100%; specificity 66–100%.⁸⁵⁻⁸⁹

Based on the available data, the accuracy of colormetric CO₂ detectors, oesophageal detector devices and non-waveform capnometers does not exceed the accuracy of auscultation and direct visualisation for confirming the tracheal

position of a tube in victims of cardiac arrest. Waveform capnography is the most sensitive and specific way to confirm and continuously monitor the position of a tracheal tube in victims of cardiac arrest and must supplement clinical assessment (auscultation and visualisation of tube through cords). Waveform capnography will not discriminate between tracheal and bronchial placement of the tube – careful auscultation is essential. Existing portable monitors make capnographic initial confirmation and continuous monitoring of tracheal tube position feasible in almost all settings, including out-of-hospital, emergency department and in-hospital locations where intubation is performed.

Cricothyroidotomy

If it is impossible to ventilate an apnoeic patient with a bag-mask, or to pass a tracheal tube or alternative airway device, delivery of oxygen through a cannula or surgical cricothyroidotomy may be life saving. A tracheostomy is contraindicated in an emergency, as it is time consuming, hazardous and requires considerable surgical skill and equipment.

Surgical cricothyroidotomy provides a definitive airway that can be used to ventilate the patient's lungs until semi-elective intubation or tracheostomy is performed. Needle cricothyroidotomy is a much more temporary procedure providing only short-term oxygenation. It requires a wide-bore, non-kinking cannula, a high-pressure oxygen source, runs the risk of barotrauma and can be particularly ineffective in patients with chest trauma. It is also prone to failure because of kinking of the cannula, and is unsuitable for patient transfer. In the 4th National Audit Project of the UK Royal College of Anaesthetists and the Difficult Airway Society (NAP4), 60% of needle cricothyroidotomies attempted failed.⁹⁰ In contrast, all surgical cricothyroidotomies achieved access to the trachea. While there may be several underlying causes, these results indicate a need for more training in surgical cricothyroidotomy and this should include regular manikin-based training using locally available equipment.⁹¹

Drugs for cardiac arrest

The ILCOR systematic reviews found insufficient evidence to comment on critical outcomes such as survival to discharge and survival to discharge with good neurological outcome with any drug during CPR.² There was also insufficient

evidence to comment on the best time to give drugs to optimise outcome.

Thus, although drugs are still included among ALS interventions, they are of secondary importance to high quality uninterrupted chest compressions and early defibrillation.

Adrenaline

Despite the continued widespread use of adrenaline during resuscitation, there is no placebo-controlled study that shows that the routine use of adrenaline during human cardiac arrest increases survival to hospital discharge, although improved short-term survival has been documented.⁹²⁻⁹⁴

The current recommendation is to continue the use of adrenaline during CPR as for Guidelines 2010. We have considered the benefit in short-term outcomes (ROSC and admission to hospital) and our uncertainty about the benefit or harm on survival to discharge and neurological outcome given the limitations of the observational studies.^{2,95,96}

Resuscitation Council UK has decided not to recommend a change to current practice until there are high quality data on long-term outcomes. Dose response and placebo-controlled efficacy trials are needed to evaluate the use of adrenaline in cardiac arrest. There is an ongoing randomised study of adrenaline vs. placebo for OHCA in the UK (PARAMEDIC 2: The Adrenaline Trial, ISRCTN73485024).

Amiodarone

No anti-arrhythmic drug given during human cardiac arrest has been shown to increase survival to hospital discharge, although amiodarone has been shown to increase survival to hospital admission.^{97,98} Despite the lack of human long-term outcome data, the balance of evidence is in favour of the use anti-arrhythmic drugs for the management of arrhythmias in cardiac arrest. There is an ongoing trial comparing amiodarone to lidocaine and to placebo designed and powered to evaluate for functional survival.⁶

Vascular access during CPR

The role of drugs during cardiac arrest is uncertain. Some patients will already have intravenous access before they have a cardiac arrest. If this is not the case ensure CPR had started and defibrillation, if appropriate, attempted before

considering vascular access.

Peripheral versus central venous drug delivery: Although peak drug concentrations are higher and circulation times are shorter when drugs are injected into a central venous catheter compared with a peripheral cannula,⁹⁹ insertion of a central venous catheter requires interruption of CPR and can be technically challenging and associated with complications. Peripheral venous cannulation is quicker, easier to perform and safer. Drugs injected peripherally must be followed by a flush of at least 20 mL of fluid and elevation of the extremity for 10–20 seconds to facilitate drug delivery to the central circulation.

Intraosseous route: If intravenous access is difficult or impossible, consider the intraosseous (IO) route. This is now established as an effective route in adults.¹⁰⁰⁻¹⁰⁸ Intraosseous injection of drugs achieves adequate plasma concentrations in a time comparable with injection through a vein.^{109,110} Animal studies suggest that adrenaline reaches a higher concentration and more quickly when it is given intravenously as compared with the intraosseous route, and that the sternal intraosseous route more closely approaches the pharmacokinetics of IV adrenaline.¹¹¹ The recent availability of mechanical IO devices has increased the ease of performing this technique.¹¹² There are several intraosseous devices available as well as a choice of insertion sites including the humerus, proximal or distal tibia, and sternum. The decision concerning choice of device and insertion site should be made locally and staff adequately trained in its use.

7. CPR techniques and devices

Please find below key information you may need regarding mechanical chest compression devices and Extracorporeal cardiopulmonary resuscitation (ECPR) :

Mechanical chest compression devices

We recommend that automated mechanical chest compression devices are not used routinely to replace manual chest compressions.

Automated mechanical chest compression devices are a reasonable alternative to high quality manual chest compressions in situations where sustained high quality manual chest compressions are impractical or compromise provider safety.²

Interruptions to CPR during device deployment should be avoided. Healthcare personnel who use mechanical CPR should do so only within a structured, monitored programme, which should include comprehensive competency-based training and regular opportunities to refresh skills.

Since Guidelines 2010 there have been three large RCTs enrolling 7,582 patients that have shown no clear advantage for the routine use of automated mechanical chest compression for OHCA using the Lund University Cardiac Arrest System (LUCAS)^{113,114} and AutoPulse devices.¹¹⁵ Ensuring high quality chest compressions with adequate depth, rate and minimal interruptions, regardless of whether they are delivered by machine or human, is important.^{116,117} Mechanical compressions usually follow a period of manual compressions;¹¹⁸ the transition from manual compressions to mechanical compressions whilst minimising interruptions to chest compression and avoiding delays in defibrillation is therefore an important aspect of using these devices. The use of training drills and 'pit-crew' techniques for device deployment are suggested to help minimise interruptions in chest compression.¹¹⁹⁻¹²¹

Extracorporeal cardiopulmonary resuscitation (ECPR)

Extracorporeal CPR (ECPR) should be considered as a rescue therapy for those patients in whom initial ALS measures are unsuccessful and, or to facilitate specific interventions (e.g. coronary angiography and percutaneous coronary intervention (PCI) or pulmonary thrombectomy for massive pulmonary embolism).^{122,123} There is an urgent need for randomised studies of ECPR and large ECPR registries to identify the circumstances in which it works best, establish guidelines for its use and identify the benefits, costs and risks of ECPR.^{124,125}

Extracorporeal techniques require vascular access and a circuit with a pump and oxygenator and can provide a circulation of oxygenated blood to restore tissue perfusion. This has the potential to buy time for restoration of an adequate spontaneous circulation, and treatment of reversible underlying conditions. This is commonly called extracorporeal life support (ECLS), and more specifically extracorporeal CPR (ECPR) when used during cardiac arrest. These techniques are becoming more commonplace and have been used for both in-hospital and out-of-hospital cardiac arrest despite limited observational data in select patient groups. Observational studies suggest ECPR for cardiac arrest is associated with improved survival when there is a reversible cause for cardiac arrest (e.g.

myocardial infarction, pulmonary embolism, severe hypothermia, poisoning), there is little comorbidity, the cardiac arrest is witnessed, the individual receives immediate high quality CPR, and ECPR is implemented early (e.g. within 1 hour of collapse) including when instituted by emergency physicians and intensivists.¹²⁶⁻¹³²

The implementation of ECPR requires considerable resource and training. When compared with manual or mechanical CPR, ECPR has been associated with improved survival after IHCA in selected patients.^{126,128} After OHCA outcomes with both standard and ECPR are less favourable.¹³³ The duration of standard CPR before ECPR is established and patient selection are important factors for success.^{122,126,130,132,134-136}

8. Duration of resuscitation attempt

If attempts at obtaining ROSC are unsuccessful the resuscitation team leader should discuss stopping CPR with the team. The decision to stop CPR requires clinical judgement and a careful assessment of the likelihood of achieving ROSC. If it was considered appropriate to start resuscitation, it is usually considered worthwhile continuing, as long as the patient remains in VF/pVT, or there is a potentially reversible cause than can be treated. The use of mechanical compression devices and extracorporeal CPR techniques make prolonged attempts at resuscitation feasible in selected patients. It is generally accepted that asystole for more than 20 minutes in the absence of a reversible cause and with ongoing ALS constitutes a reasonable ground for stopping further resuscitation attempts.¹³⁷

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10. Accreditation of the 2015 Guidelines

NICE has accredited the process used by Resuscitation Council UK to produce its Guidelines development Process Manual. Accreditation is valid for 5 years from March 2015. More information on accreditation can be viewed at <https://www.nice.org.uk/about/what-we-do/accreditation>.

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